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LUMINOUS PAINT

For many years the industrial hazards associated with the use of luminous paint have been recognized, and industry has taken steps to provide safeguards to protect the workers who handle this product. The war emergency has greatly increased the use of luminous paint and employees are exposed to gamma radiation from the use of radium in dial painting, from X-ray machines used to detect flaws in welding and other purposes.

Field evaluation of the hazard involved calls for the use of special testing apparatus and a technical knowledge not readily available. The United States Public Health Service offered the services of Dr. Frank Hoecker, physicist from the Institute of Health to make studies in a number of aircraft repair and shipbuilding plants throughout California. He has prepared a discussion of radium, its properties, method of detection and control, with particular reference to the dangers associated with luminous paint, which is reproduced herewith:

"The following is a brief discussion of certain properties of luminous substance used in the painting of the dials of aircraft instruments to make certain portions of them self-luminous. It is in no wise to be considered as a complete treatment of the subject.

The active ingredient of the paint is usually zinc sulfide, ZnS, one of a group of substances known as Phosphors. These substances have the unique property of fluorescence, that is, they will emit visible light when excited. This excitation can be produced in various ways, all of which involve the absorption of energy by the ZnS. When pure ZnS is used, it emits light only during the time it is absorbing energy, and ceases to emit practically instantly when the source of energy is removed.

If, however, a very small amount of metallic impurity is added to the pure ZnS, it then acquires the ability to emit light after the source of energy is removed. In other words, if the ZnS is exposed to light and then taken into a dark room, it will continue to emit light for some time. This property is known as phosphorescence. The length of time during which the ZnS will continue to emit light after removal of the exciting energy and the color of light emitted by the ZnS are determined by the amount and kind of impurity in the ZnS. The length of time the ZnS will emit light in darkness can not be definitely specified because the decay is logarithmic, that is, the intensity of emission decreases very rapidly at first, then more and more slowly. It is most convenient to say that the intensity decreases to some fraction of the original intensity in a certain period. For practical purposes, the useful intensity period is of the order of a minute.

It is obvious from the foregoing that the ZnS would be of no use for illuminating aircraft instrument dials unless it were more or less continuously excited. This is often done by use of ultra violet light, which, being invisible avoids a general illumination within the cabin which would tend to blind the pilot. However, failure of the ultra violet source would leave no dial illumination after a minute or so.

In order to prevent loss of instrument visibility due to failure of the exciting source, the ZnS is made self luminous by placing an exciting source, radium, within the ZnS powder itself.

Radium is able to produce luminosity in the ZnS continuously and indefinitely because of certain unique properties. Radium belongs to a class of substances whose atoms disintegrate spontaneously in varying amounts and at varying rates. The process of spontaneous disintegration is called radioactivity and is accompanied by the emission of large amounts of energy and results in the formation of a new substance from the original. Thus when a radium atom

disintegrates, it gives off energy and becomes Radon, which also is radioactive and in turn disintegrates to form Radium A and so on through a continuous process until finally an atom of lead is formed. Each disintegration event is accompanied by the emission of energy but the energy is not always emitted in the same form.

Three types of energy emission are recognized, alpha, beta and gamma rays. The alpha rays or particles as they are usually called carry relatively large amounts of energy but are not very penetrating, being stopped by a sheet of paper. Beta rays, or particles, are more penetrating, some being able to penetrate thin sheets of aluminum. The alpha particles give up all their energy within about 2 inches of air; the beta particles will penetrate several yards of air, while the gamma rays, which will penetrate several inches of lead, will travel perhaps miles in air.

It must be noted, however, that when the penetration distance of gamma rays is discussed, we meet the same difficulty we met previously in discussing the phosphorescent decay period of ZnS. The obsorption of gamma rays by substances is logarithmic, that is, even a piece of paper will absorb some of the gamma rays—a very, very small fraction, to be sure. On the other hand, some gamma rays from a given source will penetrate almost any thickness of lead or concrete. One can therefore specify only that a *certain fraction* of the *original intensity* of gamma rays will be absorbed by a given thickness of lead or concrete.

Radium is a *dangerous* substance—in certain respects more dangerous than any other agent because it is so often misunderstood, because it gives no warning, and because its effects are delayed. The application of even large quantities of radium to the skin causes no immediate discomfort—in fact causes no sensation at all for several days.

Then if, say a tenth of a gram of radium had been applied for several hours, the skin would at first become red in about a week, then the skin would gradually decay and assume the appearance of a bad burn due to a hot iron, and the same painful results would accompany the injury. Later, healing would take place just about the same as with a burn.

However, if the quantity of radium is small enough, no burn will result, but the exposure of the skin to such small quantities continuously for long periods of time will produce a gradual reddening and hardening of the skin, and, if the conditions are right, may ultimately cause cancer of the skin.

These effects discussed above are due to the absorption of the alpha, beta, and gamma rays by the skin when the radium is in contact with it. If, on the other hand, the radium is at some distance from the skin or is enclosed in metal or glass, only the effects of the gamma rays must be considered. As mentioned above, the gamma rays are hard to stop but some fraction of the original amount will be absorbed within the body through which they pass and the amount absorbed in a body depends upon the original or incident intensity since, it is recalled, a *definite fraction* of this incident intensity, whatever it may be, is absorbed in the body.

It is this absorbed portion which does the damage—destruction of tissue in the human body. And experience has shown that the body cells which are most susceptible to destruction by long time exposure to small doses of gamma rays are the bone marrow cells, the cells which produce blood corpuscles. The destruction of these cells result in anemia and serious impairment of health—ultimately death.

The intensity of gamma rays at any point can be easily measured. There are several types of instrument available for this, the choice depending on the time available for the measurement and upon the intensity at the point. The use of photographic films has been resorted to in years past but experience has shown that that method is very inaccurate and often leads to serious errors. The measurement of such low intensities of gamma rays should be undertaken only by a physicist or other specially qualified person.

Many years of experience and research have shown that the human body should *never* be continuously exposed for long periods of time to gamma ray intensities greater than 0.1 roentgens per eight hour day. The roentgen is the unit of measurement of gamma ray and x-ray quantity.

Although the amount of radium in one gram of luminous paint powder is very small, a few micrograms—the continuous handling of even a few hundred grams of the paint may be fraught with danger unless proper precautions are exercised. This statement applies equally well to the powder, the paint and to painted objects. It should be made clear that the paint after application, whether dry or not is just as dangerous—perhaps more so—as the powder. One painted dial or even ten may not constitute a hazard, but an accumulation of several hundred becomes a very real danger.

It was pointed out above that Radium disintegrates into Radon. This substance is a gas, heavier than air and fully as dangerous as the Radium from which it came. This gas is produced in the luminous paint and part of it is given off into the air. The Radon, whether it remains locked in the paint or whether given off into the air is the source of the gamma rays. If Radon is inhaled it may form a permanent destructive deposit in the body. Pure Radium which is completely freed of Radon gives off only alpha particles. But Radium does not remain free of Radon since some of the atoms are always disintegrating into Radon. *There is no known agency by which the disintegration process can be stopped, or altered in the slightest degree.*

Protection from the radium in the paint which is in use and which has already been applied is best attained by keeping the quantities small. Where large amounts must be accumulated or stored protection may be attained by storing in lead *provided* it is *sufficiently thick* or *in concrete sufficiently thick*, or by storing the large quantities at a remote point. The efficacy of lead as a protective material has been often overestimated. The thickness of lead required in a given case depends upon:

(1) The maximum quantity of paint to be stored.

(2) The minimum distance of the closest worker.

(3) The maximum time the worker will be at that point.

All these factors must be taken into account when the thickness of lead or concrete is decided upon. This, again, is usually the job of a physicist or other specially qualified person. All things being considered, distance is the best protection because of the inverse square law. This law states that the intensity at any distance from a given source is inversely proportional to the square of the distance; that is, if the distance is doubled, the intensity at that point will be only $\frac{1}{4}$ the original intensity, if the distance is trebled, the intensity will be only $\frac{1}{9}$ the original.

The matter is entirely different for lead (or concrete). To illustrate: let us suppose a given intensity at a point due to a certain amount of luminous paint. If we interpose a certain thickness of lead the intensity at the point will be reduced by a certain fraction. Let us say $\frac{1}{5}$ of the original intensity is removed; then $\frac{4}{5}$ or 80% will remain. Now double the thickness of lead (or concrete). Remembering that a given thickness always removes the same fraction of what starts through, the second sheet will obviously remove $\frac{1}{5}$ of $\frac{4}{5}$ of the original or $\frac{4}{25}$, so that the intensity after passing through both sheets will be $\frac{4}{5}$-$\frac{4}{25}$ or $\frac{16}{25}$ of the original. In percentages this, of course, becomes 80% of 80% or 64%. Doubling the thickness of lead (or concrete) reduced the intensity to 64% of the original; doubling the distance reduced the intensity to 25% of the original. In fact, 6 times the original thickness of lead would be required to reduce the intensity by the same amount as that produced by doubling the distance. In many cases, increasing the distance only slightly will reduce the intensity by the same amount as could be obtained by doubling the thickness of lead, and is usually much less expensive even if the lead were easily obtained."

SUMMARY

The following points have been discussed and should be emphasized:

(1) Radium is added to phosphorescent zinc sulfide to make itself luminous.

(2) Radium produces this luminosity because it disintegrates spontaneously and gives off energy.

(3) All of the energy given off by Radium in the form of alpha, beta, and gamma rays is destructive to human tissue.

(4) The gamma rays are ordinarily most dangerous because they are highly penetrating.

(5) Radon gas, produced in the disintegration process, is given off into surrounding air, and is the source of the gamma rays.

(6) Radon, if inhaled, may be permanently deposited in the body and cause continuous destruction of tissue.

(7) The rate of the disintegration process can not be changed by any means known to man.

(8) Luminous paint containing radium is always dangerous, whether in powder, paint or applied form.

(9) The maximum continuous exposure tolerance intensity is 0.1 roentgen per 8 hour day.

(10) Protection from Radon can be attained only by ventilation.

(11) Protection from gamma rays emitted by Radon associated with Radium is attained by avoidance of large quantities; in the case of large quantities, by sufficiently thick lead or concrete or by sufficient distance.

INDUSTRIAL NURSING CONSULTATIONS

Several conferences were held by the Industrial Nursing Consultant of the Bureau of Industrial Health with the Chief of the Bureau of Venereal Diseases, San Francisco City Health Department, and with the department's psychiatrist and psychiatrics social worker regarding their rehabilitation program for women sex delinquents. This is a unique undertaking. Psychiatric social aspects of the case are studied, and occupational possibilities explored. The important part of the program is the plan to place these women in industry under the supervision of the plant industrial nurse. The matter has been proposed to the Industrial Nursing Unit of the California State Organization for Public Health Nursing in Alameda and Contra Costa Counties, and has been favorably received.

Confidential records are to be kept by the industrial plant nurse for follow-up and guidance of these women, and a brochure is being prepared for nurses in industry to assist them in handling these cases. It is believed that in the course of a year, from 100 to 150 workers will be thus rehabilitated for the war production drive.

The Extension Course for Industrial Nursing at the University of California has continued and the final lecture of this series will be given on December 22d. Arrangements have been made to repeat the course on the Berkeley campus for the benefit of nurses working on the night shift. The time set is Tuesdays, from 10 a.m. to 12 noon, beginning January 19, 1943. A similar course will be given Tuesday evenings from 7.30 to 9.30 at San Jose for San Jose and Santa Clara public health and industrial nurses.

EPIDEMIC KERATOCONJUNCTIVITIS

There are indications of sporadic cases of "shipyard eye"; those now being reported are milder than those of a year ago. A number of requests have come in for assistance from the office of Civilian Defense, Ninth Civilian Defense Region; from the newly established Division of Industrial Hygiene in the State of Washington; and from as far away as Charlotte, North Carolina. The statement concerning the symptoms and treatment has been prepared for distribution and for possible publication.

MORBIDITY*

Complete Reports for Certain Diseases Recorded for Week Ending December 5, 1942

Chickenpox

773 cases from the following counties: Alameda 93, Colusa 7, Contra Costa 5, Fresno 17, Humboldt 1, Kern 16, Lassen 3, Los Angeles 145, Madera 5, Marin 28, Modoc 34, Monterey 21, Napa 3, Orange 9, Riverside 28, Sacramento 55, San Bernardino 8, San Diego 69, San Francisco 57, San Joaquin 44, San Luis Obispo 2, San Mateo 7, Santa Clara 40, Solano 6, Sonoma 11, Sutter 4, Tehama 18, Tulare 24, Yolo 13.

German Measles

45 cases from the following counties: Alameda 3, Los Angeles 9, Modoc 20, Orange 1, Sacramento 1, San Bernardino 2, San Diego 1, San Francisco 4, Santa Clara 1, Tulare 3.

Measles

78 cases from the following counties: Alameda 6, Fresno 2, Kern 2, Los Angeles 12, Marin 1, Merced 2, Modoc 21, Monterey 1, Sacramento 1, San Bernardino 2, San Diego 2, San Francisco 10, San Mateo 12, Santa Clara 1, Shasta 1, Sonoma 1, Yolo 1.

Mumps

374 cases from the following counties: Alameda 42, Contra Costa 3, El Dorado 1, Fresno 11, Glenn 1, Humboldt 12, Kern 5, Kings 1, Los Angeles 118, Madera 5, Merced 2, Modoc 1, Napa 3, Orange 14, Riverside 9, Sacramento 10, San Bernardino 14, San Diego 41, San Francisco 27, San Joaquin 7, San Luis Obispo 4, San Mateo 10, Santa Barbara 1, Santa Clara 15, Solano 1, Sutter 1, Tuolumne 1, Yolo 14.

Scarlet Fever

157 cases from the following counties: Alameda 5, Fresno 2, Kern 18, Lassen 17, Los Angeles 64, Madera 1, Marin 1, Merced 1, Orange 6, Sacramento 5, San Bernardino 1, San Diego 9, San Francisco 8, San Joaquin 2, Santa Clara 11, Solano 1, Tulare 2, Yuba 3.

Whooping Cough

234 cases from the following counties: Alameda 41, Contra Costa 4, Humboldt 4, Kern 17, Los Angeles 93, Orange 11, Riverside 3, Sacramento 6, San Bernardino 4, San Diego 23, San Francisco 16 San Joaquin 4, San Luis Obispo 1, Santa Barbara 2, Santa Clara 1, Santa Cruz 2, Sonoma 2.

Diphtheria

31 cases from the following counties: Los Angeles 8, Monterey 1, Napa 1, Sacramento 8, San Bernardino 6, San Joaquin 3, Santa Clara 1, Solano 1, Tulare 1, Yolo 1.

Epilepsy

39 cases from the following counties: Alameda 1, Humboldt 1, Los Angeles 25, Napa 1, Sacramento 2, San Bernardino 1, San Diego 1, San Francisco 3, San Mateo 1, Sonoma 3.

Botulism

One case from Los Angeles County.

Dysentery (Bacillary)

8 cases from the following counties: Los Angeles 5, San Francisco 1, Sonoma 2.

Encephalitis (Infectious)

2 cases from Tulare County.

Food Poisoning

2 cases from Los Angeles County.

Influenza (Epidemic)

27 cases reported in the State.

Coccidioidal Granuloma

One case from Los Angeles County.

Jaundice (Infectious)

One case from Los Angeles County.

Malaria

One case from Marin County.

Meningitis (Meningococcic)

5 cases from the following counties: Alameda 1, Los Angeles 2, Sacramento 1, San Francisco 1.

Paratyphoid Fever

One case: California.**

Pneumonia (Infectious)

63 cases reported in the State.

Poliomyelitis (Acute Anterior)

19 cases from the following counties: Glenn 1, Los Angeles 15, Orange 1, Santa Barbara 1, Santa Clara 1.

Rabies (Animal)

7 cases from the following counties: Fresno 4, Los Angeles 2, Monterey 1.

Rheumatic Fever (Acute)

2 cases from the following counties: Los Angeles 1, Shasta 1.

Typhoid Fever

5 cases from the following counties: Los Angeles 3, Riverside 1, California 1.**

Undulant Fever

One case from Fresno County.

* Data regarding the other reportable diseases not listed herein, may be obtained upon request.

** Cases charged to "California" represent patients ill before entering the State or those who contracted their illness traveling about the State throughout the incubation period of the disease. These cases are not chargeable to any one locality.

MEN AT WAR

The following members of the staff of the California State Department of Public Health are with the armed services:

Ray Atkinson, M.D.
Lloyd Bascom
Paul Billings
Alcor Browne
Donald Budie
O. L. Butterfield
Beckwith Clark
Jules Comroe, M.D.
Leon Comroe, M.D.
Joseph Copeland
John Cruzan
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